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Oak Ridge National Laboratory

Health Physics Division

# APPLIED HEALTH PHYSICS SEMI-ANNUAL REPORT

July 1956 - December 1956



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## SECTION I. AREA MONITORING

### Part A. Salient and Non-Routine Items

Based on samples collected by continuous air monitors, the weekly average value for air contamination in the Laboratory area was $1.98 \times 10^{-12}$ μc/cc. This value is 45% less than the average for the last half year period. The highest average air contamination recorded by a single air monitor for a given week was $1.33 \times 10^{-11}$ μc/cc, which is a factor of $7.5 \times 10^{2}$ less than the maximum permissible concentration of beta-gamma activity.

A significant increase in particle concentration measured by continuous air monitors was observed during the first half of the period. This increase was probably due in part to weapons test fallout; however, decay and absorption studies indicated much of it to be Laboratory originated. Inquiry revealed the filters following the Cottrell precipitator in the Isotope stack area off-gas system to have been eaten away by acid laden off-gases. The remains of the filters had been removed and the filters not replaced for a period of time. A considerable decrease in particle concentration was noted following replacement of these filters. Fig. 1 is a plot of the average Laboratory area particle count, and Fig. 2 is a plot of the average particle count observed at the perimeter stations. The high activity during the first half of the period and the drop-off during the last half may be observed in both areas. The average activity for the Laboratory during the period was 2.75 particles per 1000 $ft^3$ of air sampled, which is 73% greater than the average for the last period and 99% greater than the average for last year. The highest average particle count on a single air monitor was 39.9 particles per 1000 $ft^3$ and occurred during the week ending July 9. The highest average particle count for the Laboratory area for a given week was 9.1 particles per 1000 $ft^3$ and occurred during the week ending July 30.

Radioactive fallout is determined by measuring the total activity and total number of particles collected on gum paper fallout trays. A tray is located at each of the monitoring stations and consists of a cellophane sheet one square foot in area with a gummed surface on one side. The gum paper is mounted on an aluminum shelf or tray with the gummed side facing upward. Trays are collected weekly and assayed for activity. Figs. 3 and 4 are plots of the fallout expressed in particles per square foot on a weekly basis for the Laboratory area and the perimeter area respectively. Figs. 5 and 6 are plots of the total activity in terms of μc/sq. ft. on a weekly basis. The average total fallout activity measured at three stations more remotely located from the Laboratory is plotted in Fig. 7.

Two peak periods of activity appear to correlate well throughout the data presented. The week ending July 15 was the highest fallout activity encountered and is reflected on each plot. The week ending September 23 is the second week of peak activity noted on all plots except that for the more remote stations where the peak activity occurred in the preceding week. This may be explained by the earlier arrival of fallout at the Berea station in the latter part of the week ending September 16 and overlapping into the week ending September 23. The consistency of the data lends support to the conclusion that activity measured during these two periods was the result of weapons' tests.

The greater amount of fallout activity experienced on the Laboratory area during the first half of the period resulted from Laboratory operations, some explanation for which was given above.

Radioactivity associated with rain water is measured from samples collected on a weekly basis at seven perimeter stations and at one station on the Laboratory area. Plots of the data from these measurements are presented in Fig. 8 and Fig. 9. Peak activities for the period occurred during the weeks ending July 15 and September 23 which correlates with the peak activities found by fallout measurements.

The fluctuation in the weekly average concentration of radioactive contaminants in the Clinch River is illustrated in Fig. 10. From Fig. 11, it may be seen that the operating limit of $10^{-7}$ μc/cc for gross beta concentration in the Clinch River was exceeded 31% of the time during the period. The total beta curies discharged from White Oak Creek to the Clinch River was 36.3% less than the total discharged during the last period. Only one incident of accidental release of activity from the Laboratory occurred this period. This accidental release took place during the week ending November 4. Manipulation of White Oak Dam gates and subsequent run-off from considerable rainfall provided sufficient holdup and dilution such that by slow release it was possible to maintain the weekly average concentration in the Clinch River below MPCw. The MPCw was exceeded only during the week ending December 16 as illustrated in Fig. 12. The high concentration during this week was caused primarily by the scouring of activity from White Oak Lake bed by the run-off from a 8.38 inch rainfall on December 12 through 14. Controlled release of volumes of water such as those encountered in this run-off is impossible with the current dam and lake facilities.

Area background measurements were made and reported on a monthly basis. The average monthly background for the period was 14.5% greater than last period's average but 10.5% less than the average for last year.

The Laundry Monitoring unit checked 110,767 garments for contamination during the period. In addition, 82,430 special items such as towels, gloves, shoe covers, caps, etc. were checked for contamination. Of the garments checked, 22,963 were found to be above maximum permissible limits. The weekly average fluctuation in per cent contaminated khaki garments is present in Fig. 13. Only 1.4% of the garments going to commercial laundries for cleaning were found to be contaminated above maximum permissible limits. It is of interest to note that this is the lowest number of contaminated garments of this type for a given period since the policy of sending clothing to commercial laundries was instituted.

The Environs Group completed the field work of the 1956 survey for radioactivity in the Clinch and Tennessee Rivers during this period. Gamma measurements were made of the bottom sediment contamination along 13 cross sections in the Clinch River and 8 cross sections in the Tennessee River. Mud was collected from the bottom along each cross section and brought to the Laboratory for analysis of the contaminants. When Laboratory work has been completed, the results of this survey and previous surveys made by the Environs Group will be published in a final report. Results of future surveys will be included in the appropriate Applied Health Physics semi-annual report.

A study of natural radioactive elements in the TVA lake waters was begun during this period. Composite samples are collected by TVA personnel at dams and brought to the Laboratory for analysis on a quarterly basis. Analyses are being run on both liquid and suspended solid phases. A composite sample collected at Center's Ferry on the Clinch River at Kingston will be analyzed for long lived fission products as well as natural radioactive elements. Work on this study is progressing and will continue for a tentative period of one year.

Part B. Statistical Data

1. Air Activity

a. Constant Air Monitors

(1). Laboratory Area

Average Long Lived Activity

| Station Number | Location | Weekly Av. to Date this year Conc. x $10^{-13}$ μc/cc | Deviation from 1955 Weekly Av. |
|---|---|---|---|
| HP-1 | N 3550 | 35.36 | - 76.1% |
| HP-2 | S 3001 | 18.47 | - 66.5% |
| HP-3 | S 1000 | 21.17 | - 39.7% |
| HP-4 | W 3513 | 24.63 | + 41.1% |
| HP-5 | E 2506 | 98.69 | - 32.7% |
| HP-6 | SE 3012 | 13.82 | - 34.0% |
| HP-7 | W 7001 | 14.09 | - 17.7% |
| HP-8 | Rock Quarry | 9.47 | + 17.8% |
| HP-9 | A-10 Site | 15.15 | - 10.4% |
| HP-10 | E 2074 | 28.37 | - 1.7% |
| Average | | 27.92 | |

Deviation of this year's average long lived activity to date from last year's average - 43.5%

(2). Perimeter Area

| Station Number | Location | Average Long Lived Activity: Weekly Av. to Date this year Conc. x $10^{-13}$ μc/cc | Deviation from 1955 Weekly Av. |
|---|---|---|---|
| HP-11 | Kerr Hollow Gate | 8.41 | |
| HP-12 | Mid-Way Gate | 4.95 | |
| HP-13 | Gallahar Gate | 6.35 | |
| HP-14 | White Wing Gate | 6.55 | |
| HP-15 | Blair Gate | 7.22 | |
| HP-16 | Turnpike Gate | 6.78 | |
| HP-17 | Hickory Creek Bend | 8.50 | |

(3). Remote Area

| | | | |
|---|---|---|---|
| B | Berea, Kentucky | 10.61 | |
| C | Corryton, Tennessee | 11.27 | |
| K | Kingston, Tennessee | 9.54 | |

2. Particle Studies

a. Constant Air Monitor Filters

(1). Laboratory Area

| Station Number | Location | Particle Distribution-Weekly Average Number of Particles — *Activity Ranges - Dis/24 Hours: *$<10^5$ | $10^5$ - $10^6$ | $10^6$-$10^7$ | $>10^7$ | Total | Weekly Av. to date this year Particles Per 1000 cu. ft. | Deviation of Wkly. Av. to Date this Year from Wkly. Av. Last Year |
|---|---|---|---|---|---|---|---|---|
| HP-1 | N 3550 | 112.38 | 3.04 | 0.00 | 0.02 | 115.44 | 2.94 | + 60.7% |
| HP-2 | S 3001 | 84.59 | 2.58 | 0.12 | 0.00 | 78.29 | 1.73 | + 27.2% |
| HP-3 | S 1000 | 65.38 | 2.92 | 0.06 | 0.02 | 68.38 | 1.36 | + 38.8% |
| HP-4 | W 3513 | 56.85 | 3.00 | 0.07 | 0.00 | 59.92 | 1.64 | +137.7% |
| HP-5 | E 2506 | 318.98 | 3.92 | 0.15 | 0.02 | 323.07 | 5.85 | + 67.1% |
| HP-6 | SE 3012 | 56.92 | 1.71 | 0.06 | 0.00 | 58.69 | 1.13 | + 25.6% |
| HP-7 | W 7001 | 49.35 | 2.38 | 0.00 | 0.00 | 51.73 | 1.17 | + 46.2% |
| HP-8 | Rock Quarry | 40.84 | 1.60 | 0.06 | 0.00 | 42.50 | 0.91 | - 13.3% |
| HP-9 | A-10 Site | 52.75 | 1.98 | 0.10 | 0.00 | 54.83 | 1.40 | + 14.8% |
| HP-10 | E 2074 | 116.96 | 2.10 | 0.06 | 0.00 | 119.12 | 3.31 | +129.9% |
| Average | | | | | | | 2.13 | |
| Deviation of this year's weekly average to date from weekly average last year | | | | | | | | + 55.1% |

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(2) Perimeter Area

Particle Distribution-Wkly.
Average Number of Particles

| Station Number | Location | *Activity Ranges - Dis/24 Hours $* < 10^5$ | $10^5$-$10^6$ | $10^6$-$10^7$ | $>10^7$ | Total | Wkly. Av. to date this year Particles per 1000 cu. ft. | Deviation of Wkly. Av. to date this year from Wkly. Av. last year |
|---|---|---|---|---|---|---|---|---|
| HP-11 | Kerr Hollow Gate | 36.23 | 0.98 | 0.12 | 0.00 | 37.33 | 0.77 | |
| HP-12 | Mid-Way Gate | 24.53 | 0.70 | 0.04 | 0.00 | 25.27 | 0.51 | |
| HP-13 | Gallaher Gate | 25.16 | 1.31 | 0.00 | 0.00 | 26.47 | 0.56 | |
| HP-14 | White Wing Gate | 25.38 | 2.04 | 0.04 | 0.00 | 27.46 | 0.56 | |
| HP-15 | Blair Gate | 25.59 | 2.14 | 0.09 | 0.00 | 27.82 | 0.56 | |
| HP-16 | Turnpike Gate | 34.70 | 1.18 | 0.06 | 0.00 | 35.94 | 0.72 | |
| HP-17 | Hickory Creek Bend | 48.75 | 0.96 | 0.08 | 0.00 | 49.79 | 0.99 | |

(3) Remote Area

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| B | Berea, Kentucky | 8.83 | 0.27 | 0.02 | 0.00 | 9.22 | 0.83 |
| C | Corryton, Tenn. | 12.10 | 0.25 | 0.00 | 0.00 | 12.35 | 1.22 |
| K | Kingston, Tenn. | 7.77 | 0.18 | 0.02 | 0.00 | 7.97 | 0.79 |

b. Gum Paper Fallout Trays

(1) Laboratory Area

Particle Distribution-Weekly
Average Number of Particles

| Station Number | Location | *Activity Ranges - Dis/24 Hours $* < 10^5$ | $10^5$- $10^6$ | $10^6$- $10^7$ | $>10^7$ | Particles Per Sq. Ft. Weekly Av. |
|---|---|---|---|---|---|---|
| HP-1 | N 3550 | 112.58 | 5.69 | 0.19 | 0.08 | 118.54 |
| HP-2 | S 3001 | 188.65 | 5.42 | 0.23 | 0.12 | 194.42 |
| HP-3 | S 1000 | 145.23 | 3.11 | 0.00 | 0.04 | 148.38 |
| HP-4 | W 3513 | 153.33 | 23.73 | 0.13 | 0.00 | 177.19 |
| HP-5 | E 2506 | 339.23 | 8.15 | 0.23 | 0.00 | 347.61 |
| HP-6 | SE 3012 | 99.19 | 10.38 | 0.23 | 0.00 | 109.80 |
| HP-7 | W 7001 | 139.77 | 1.54 | 0.11 | 0.00 | 141.42 |
| HP-8 | Rock Quarry | 86.15 | 2.92 | 0.08 | 0.00 | 89.15 |
| HP-9 | A-10 Site | 123.65 | 2.88 | 0.08 | 0.00 | 126.61 |
| HP-10 | E 2074 | 121.19 | 6.04 | 0.15 | 0.00 | 127.38 |

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(2) Perimeter Area

Particle Distribution-Weekly
Average Number of Particles

| Station Number | Location | *Activity Ranges - Dis/24 Hours: *$<10^5$ | $10^5$ - $10^6$ | $10^6$ - $10^7$ | $>10^7$ | Particles Per Sq. Ft. Weekly Av. |
|---|---|---|---|---|---|---|
| HP-11 | Kerr Hollow Gate | 75.31 | 5.96 | 0.00 | 0.00 | 81.27 |
| HP-12 | Mid-Way Gate | 145.88 | 4.23 | 0.04 | 0.00 | 150.15 |
| HP-13 | Gallaher Gate | 139.77 | 9.88 | 0.00 | 0.00 | 149.65 |
| HP-14 | White Wing Gate | 97.19 | 3.19 | 0.00 | 0.00 | 100.38 |
| HP-15 | Blair Gate | 116.54 | 12.65 | 0.00 | 0.00 | 129.19 |
| HP-16 | Turnpike Gate | 107.00 | 4.69 | 0.12 | 0.04 | 111.85 |
| HP-17 | Hickory Creek Bend | 67.19 | 9.62 | 0.04 | 0.00 | 76.85 |
| | (3) Remote Area | | | | | |
| B | Berea, Kentucky | 30.96 | 5.80 | 0.35 | 0.04 | 37.15 |
| C | Corryton, Tenn. | 15.67 | 5.14 | 0.05 | 0.00 | 20.86 |
| K | Kingston, Tenn. | 64.35 | 6.09 | 0.04 | 0.00 | 70.48 |

3. Liquid Waste

a. Curies Discharged

| | Settling Basin Beta | White Oak Lake Beta |
|---|---|---|
| Weekly Av. to date this year | 4.89 | 11.20 |
| Deviation from 1955 weekly average | + 15.9% | + 35.9% |

b. Submersion Data

| | Settling Basin | | | White Oak Lake | | |
|---|---|---|---|---|---|---|
| | Beta mrep/hr | Gamma mr/hr | Total mr(ep)hr | Beta mrep/hr | Gamma mr/hr | Total mr(ep)hr |
| Weekly Av. to date this year | 0.308 | 0.265 | 0.573 | 0.042 | 0.034 | 0.076 |
| Deviation from 1955 Weekly Av. | 0.0% | + 1.1% | + 0.5% | + 10.5% | + 54.5% | + 26.7% |

c. Plutonium Discharged

| | Settling Basin | | White Oak Lake | |
|---|---|---|---|---|
| | Conc. x $10^{-9}$ μg/cc | Total mg Plutonium | Conc. x $10^{-9}$ μg/cc | Total mg Plutonium |
| Weekly Av. to date this yr. | 3105.9 | 110.410 | 440.7 | 88.518 |
| Deviation from 1955 weekly average | - 19.9% | + 89.9% | + 45.9% | + 16.2% |

d. Probable average concentration in Clinch River below White Oak Creek using as a dilution factor the ratio of White Oak Lake discharge to the flow of Clinch River.

| | |
|---|---|
| Weekly average to date this year | $1.51 \times 10^{-7}$ μc/cc |
| Deviation from 1955 weekly average | + 20.8% |

4. Meteorological Data

a. Rainfall

| | |
|---|---|
| Total this year | 60.93 inches |
| Normal yearly rainfall | 52.58 inches |
| Deviation from normal seasonal rainfall | + 15.9% |

5. Laundry Decontamination Measurements

| | Weekly average to date this year | Deviation of this year's weekly average from 1955 weekly av. |
|---|---|---|
| a. Garments | 4,085 | + 5.7% |
| b. Special Items | 3,180 | + 34.5% |

Figure 1

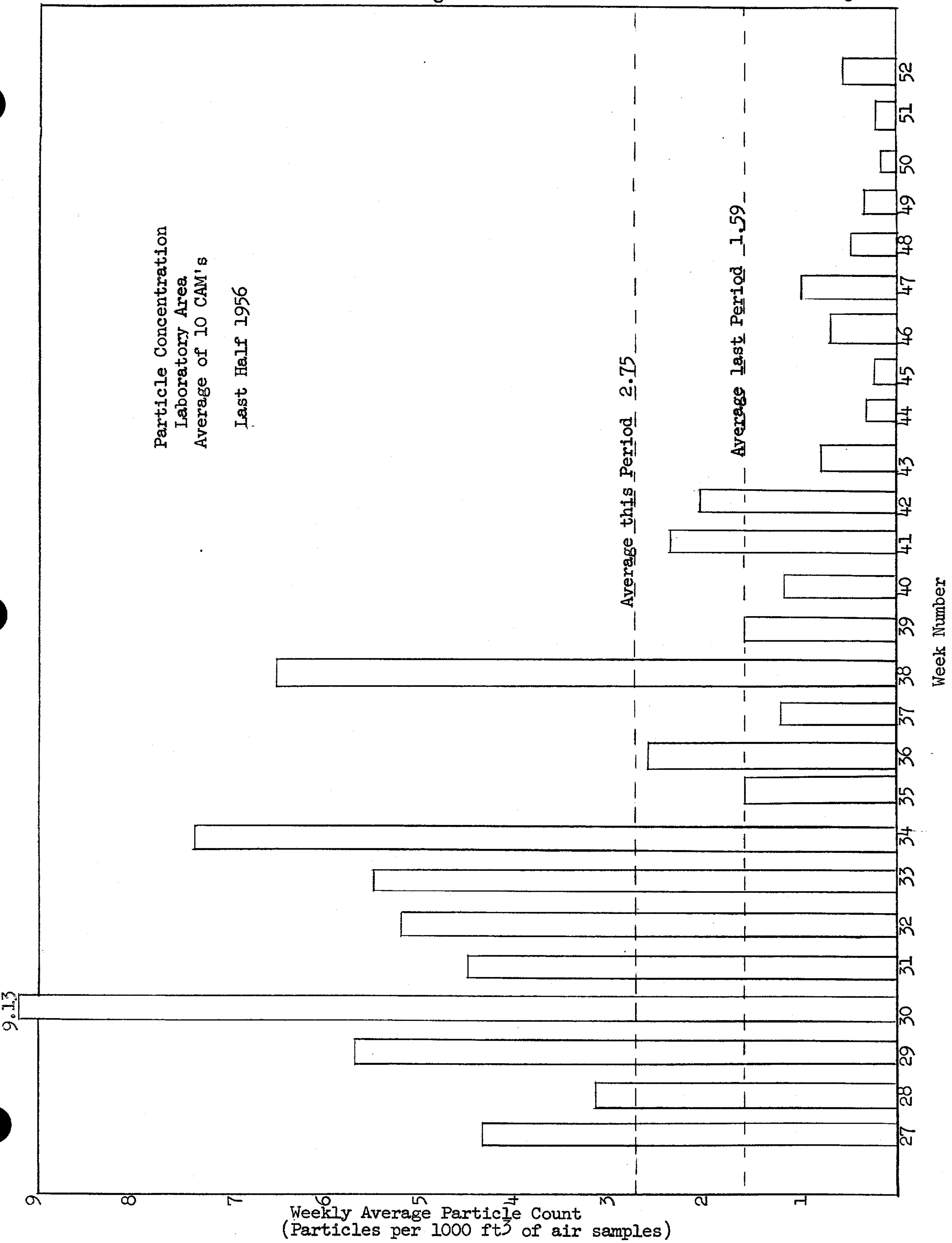
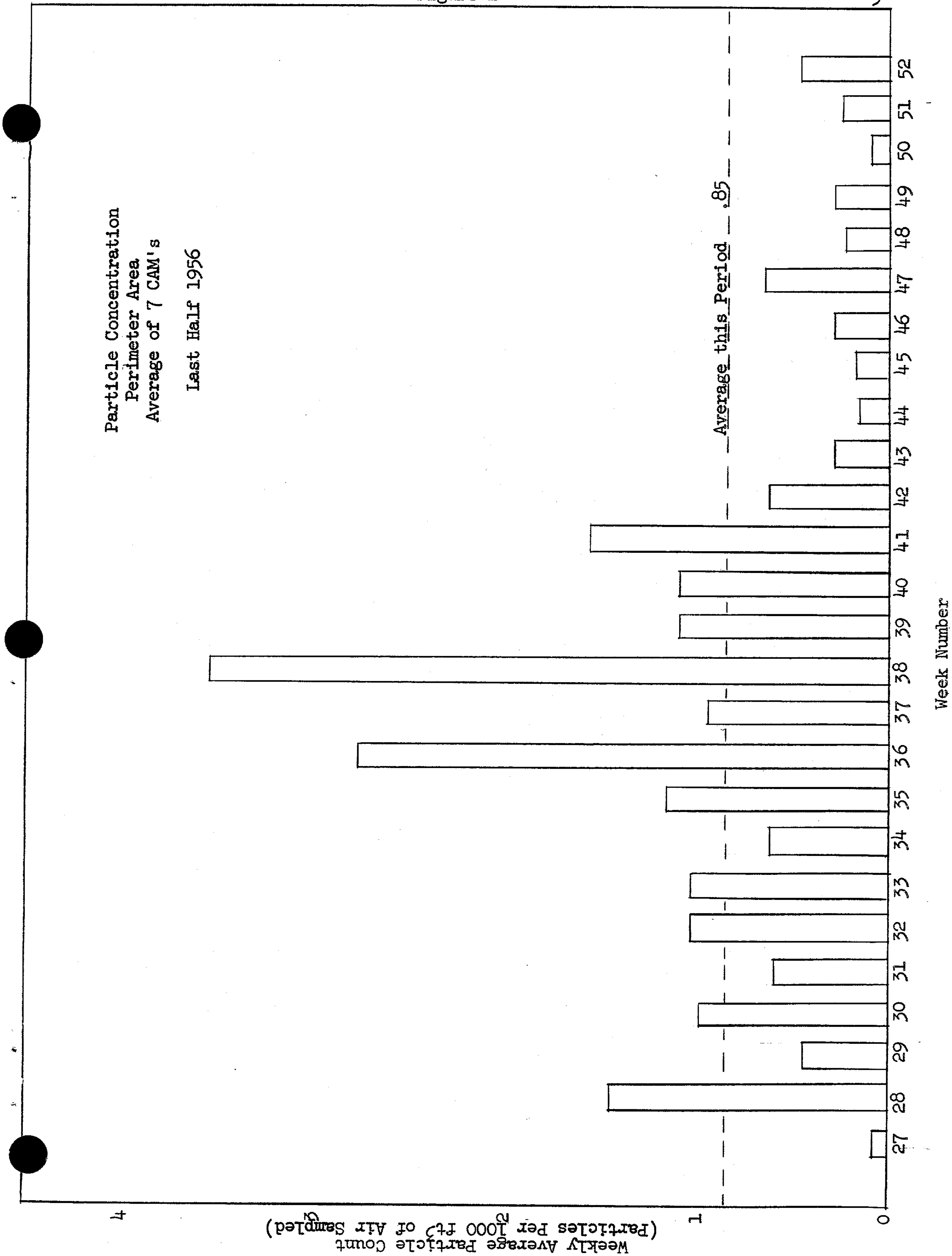

Particle Concentration
Laboratory Area
Average of 10 CAM's
Last Half 1956
Average this Period 2.75
Average last Period 1.59
9.13
Week Number
27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52
9 8 7 6 5 4 3 2 1
Weekly Average Particle Count
(Particles per 1000 ft3 of air samples)

Figure 2


Particle Concentration
Perimeter Area
Average of 7 CAM's
Last Half 1956
Average this Period .85
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
Week Number
0
1
2
3
4
Weekly Average Particle Count
(Particles Per 1000 ft³ of Air Sampled)

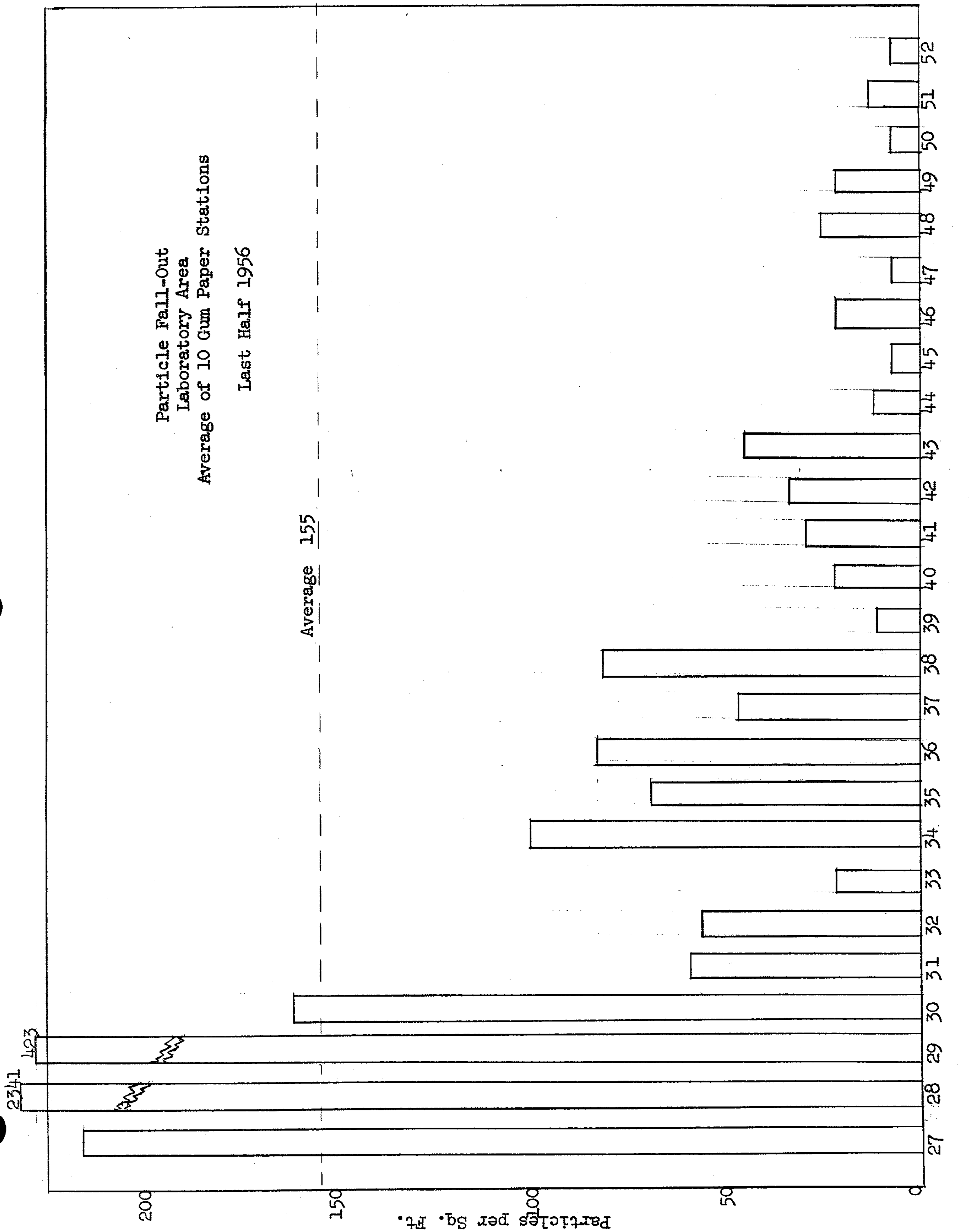

Particle Fall-Out
Laboratory Area
Average of 10 Gum Paper Stations
Last Half 1956
Average 155
423
2341
27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52
0 50 100 150 200
Particles per Sq. Ft.

Figure 4

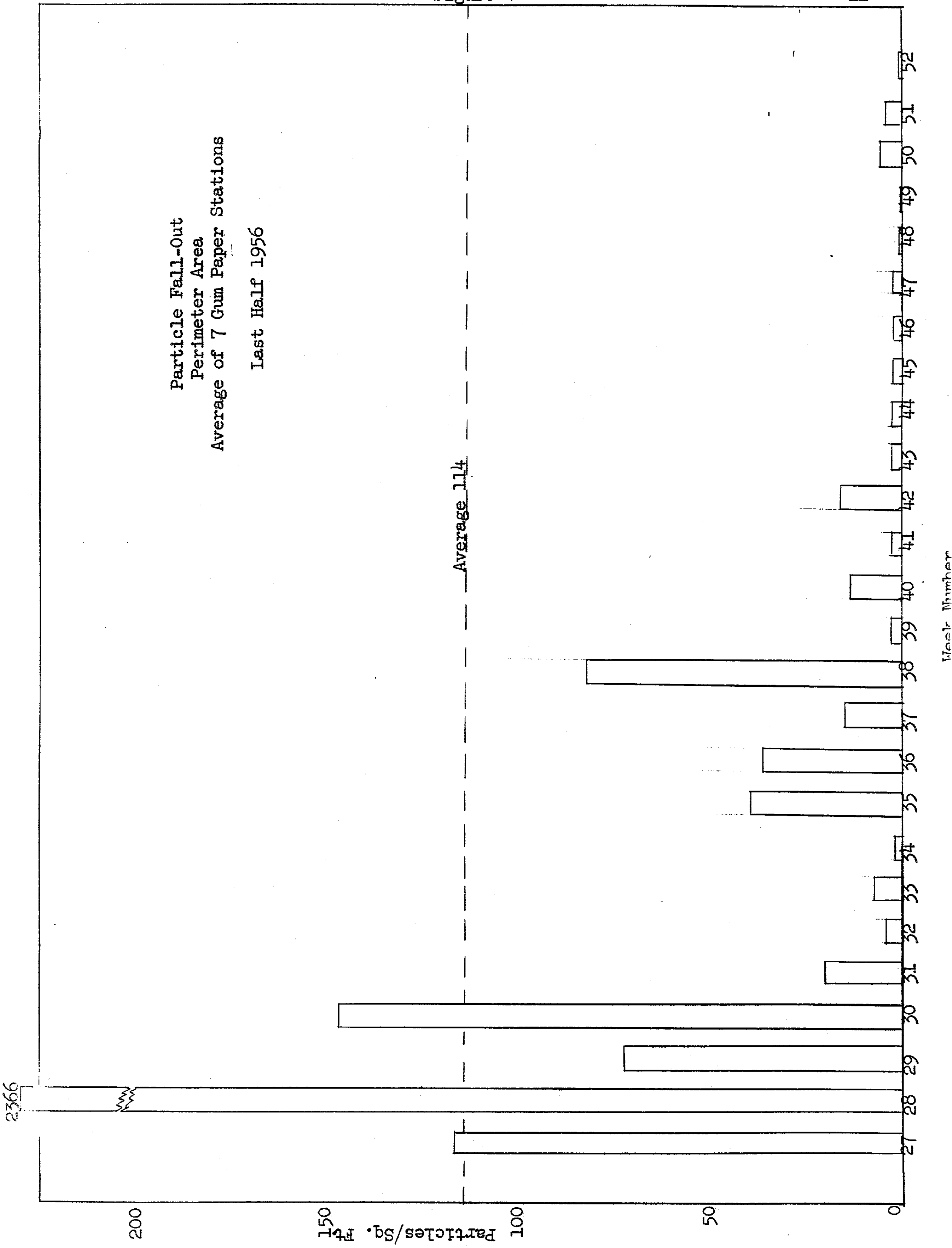

Particle Fall-Out
Perimeter Area
Average of 7 Gum Paper Stations
Last Half 1956
Average 114
2366
200
150
100
50
0
Particles/Sq. Ft.
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
Week Number

Figure 5

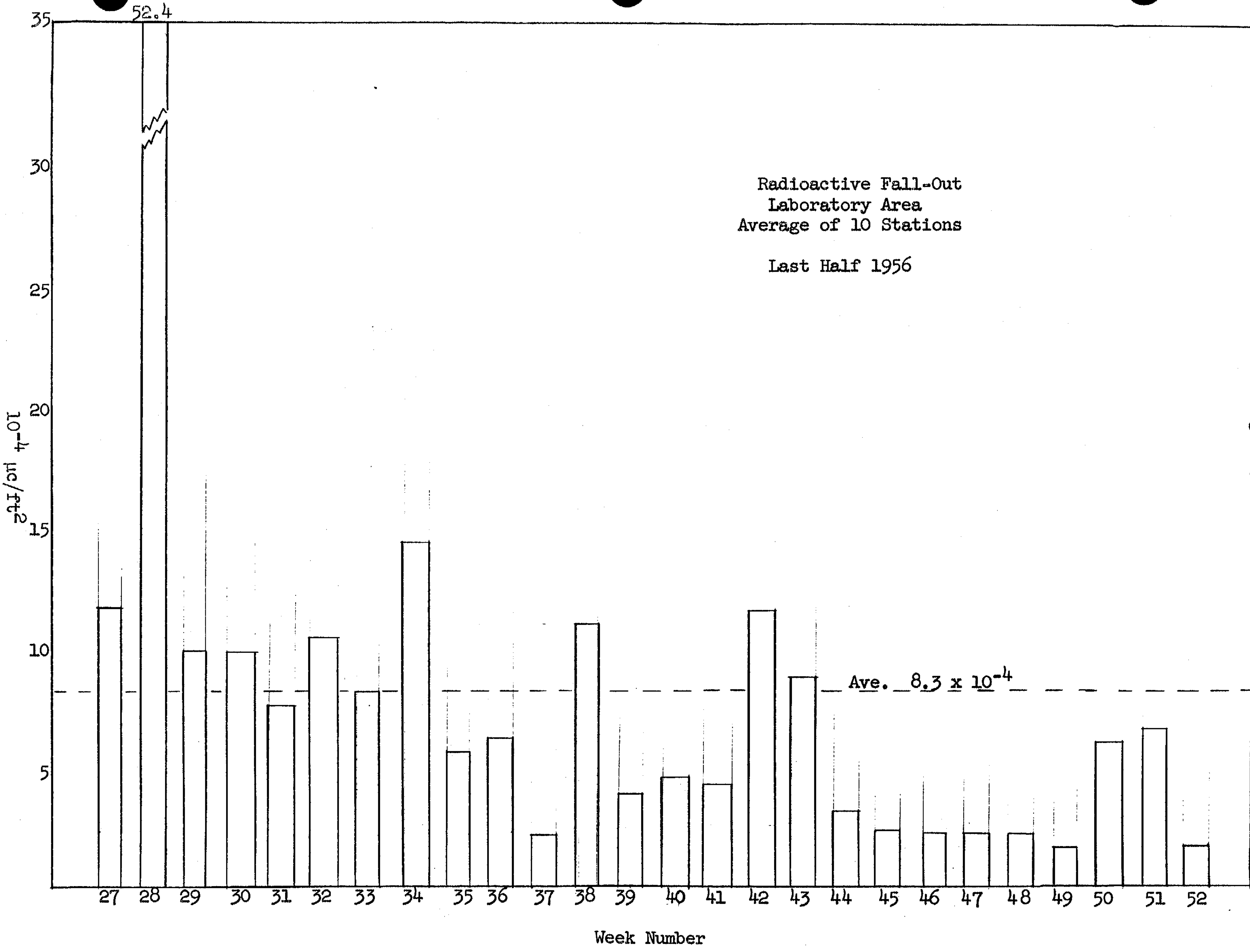
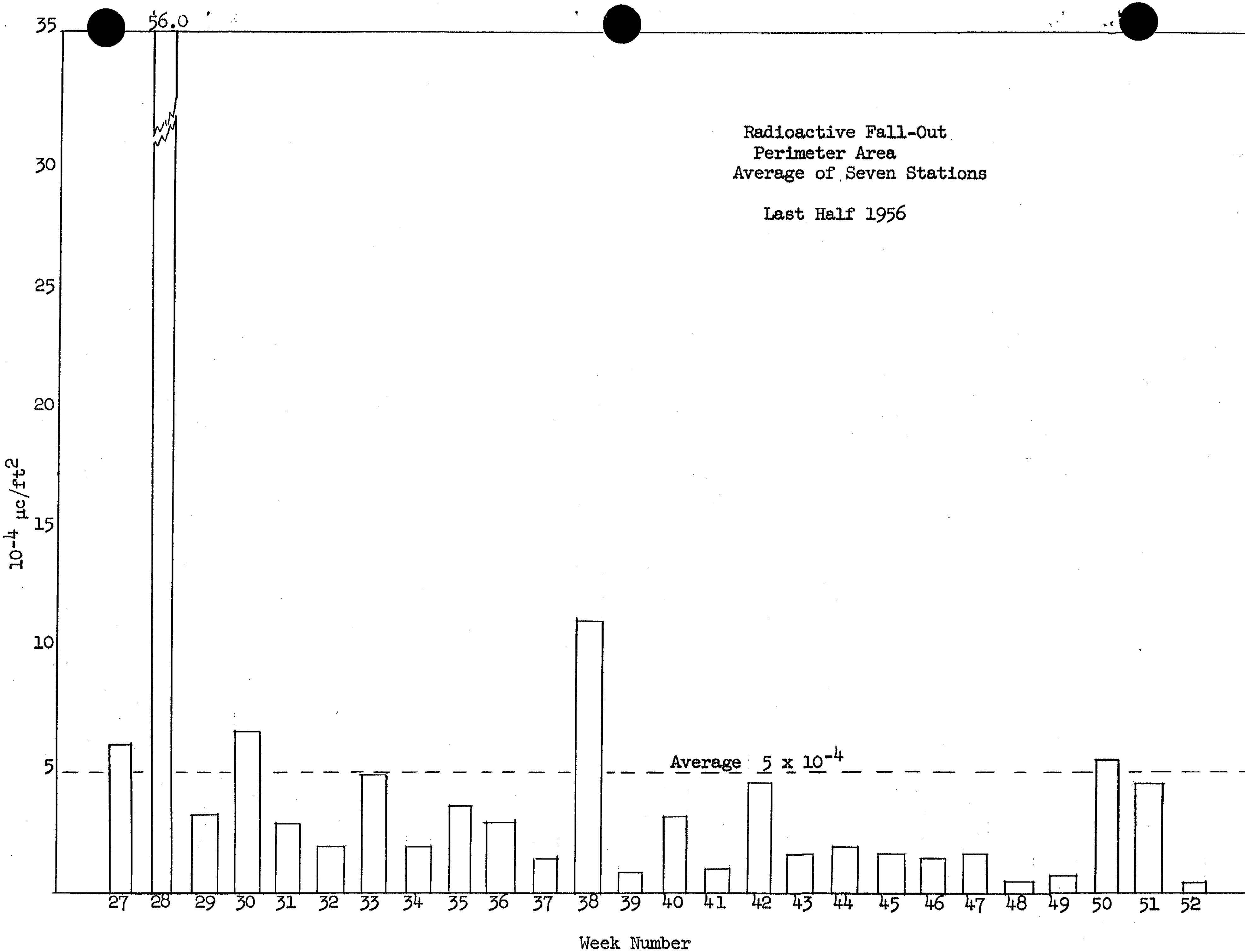
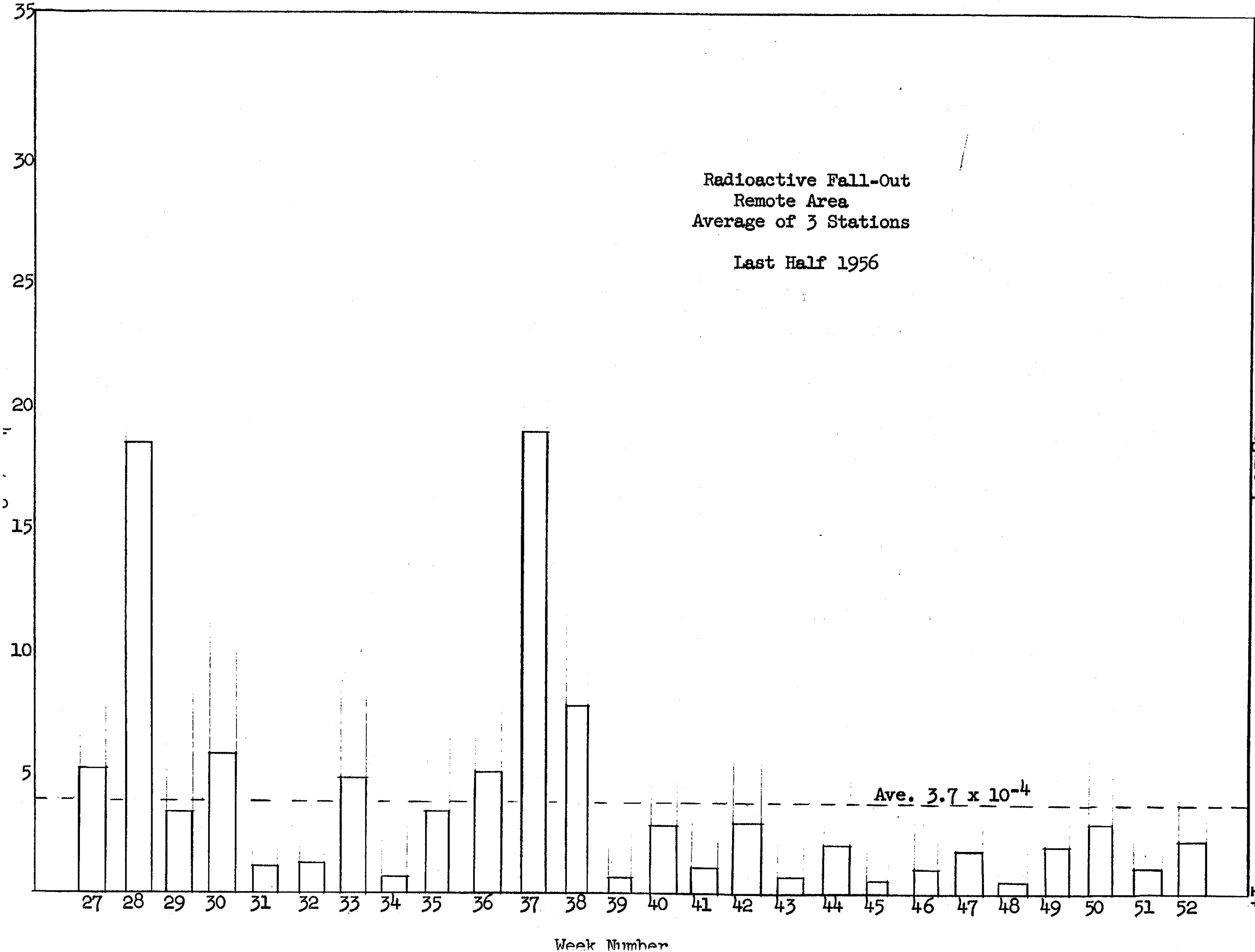

Radioactive Fall-Out
Laboratory Area
Average of 10 Stations
Last Half 1956
Ave. 8.3 x $10^{-4}$
52.4
35
30
25
20
15
10
5
$10^{-4}$ $\mu c/ft^2$
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
Week Number

Figure 6


Radioactive Fall-Out
Perimeter Area
Average of Seven Stations
Last Half 1956
56.0
Average 5 x $10^{-4}$
$10^{-4}$ µc/ft²
35
30
25
20
15
10
5
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
Week Number


Radioactive Fall-Out
Remote Area
Average of 3 Stations
Last Half 1956
Ave. 3.7 x 10-4
35
30
25
20
15
10
5
27
28
29
30
31
32
33
34
35
36
37
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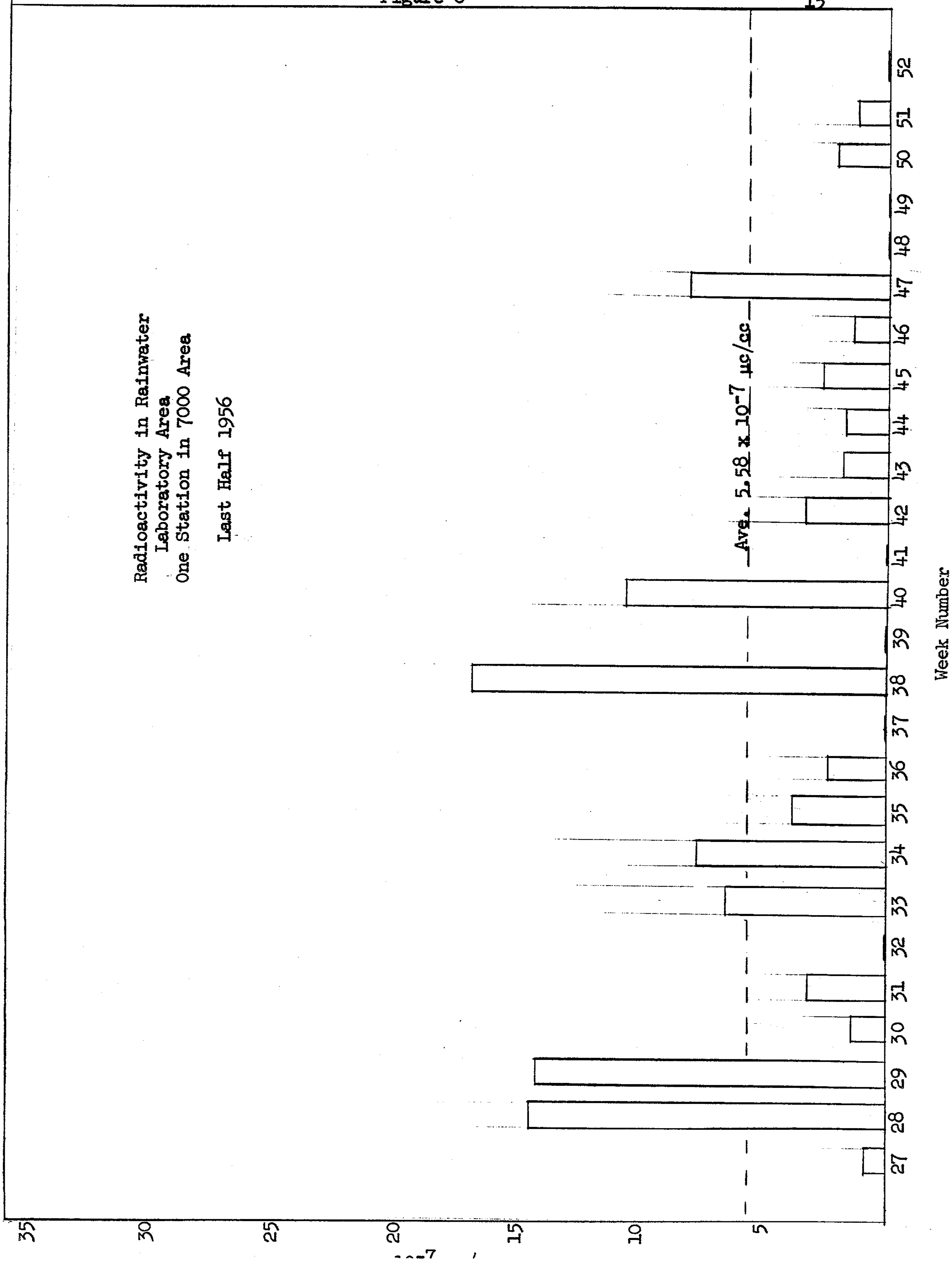
39
40
41
42
43
44
45
46
47
48
49
50
51
52
Week Number

Figure 8





Radioactivity in Rainwater
Laboratory Area
One Station in 7000 Area
Last Half 1956
Ave. 5.58 x 10-7 µc/cc
Week Number
27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52
5 10 15 20 25 30 35

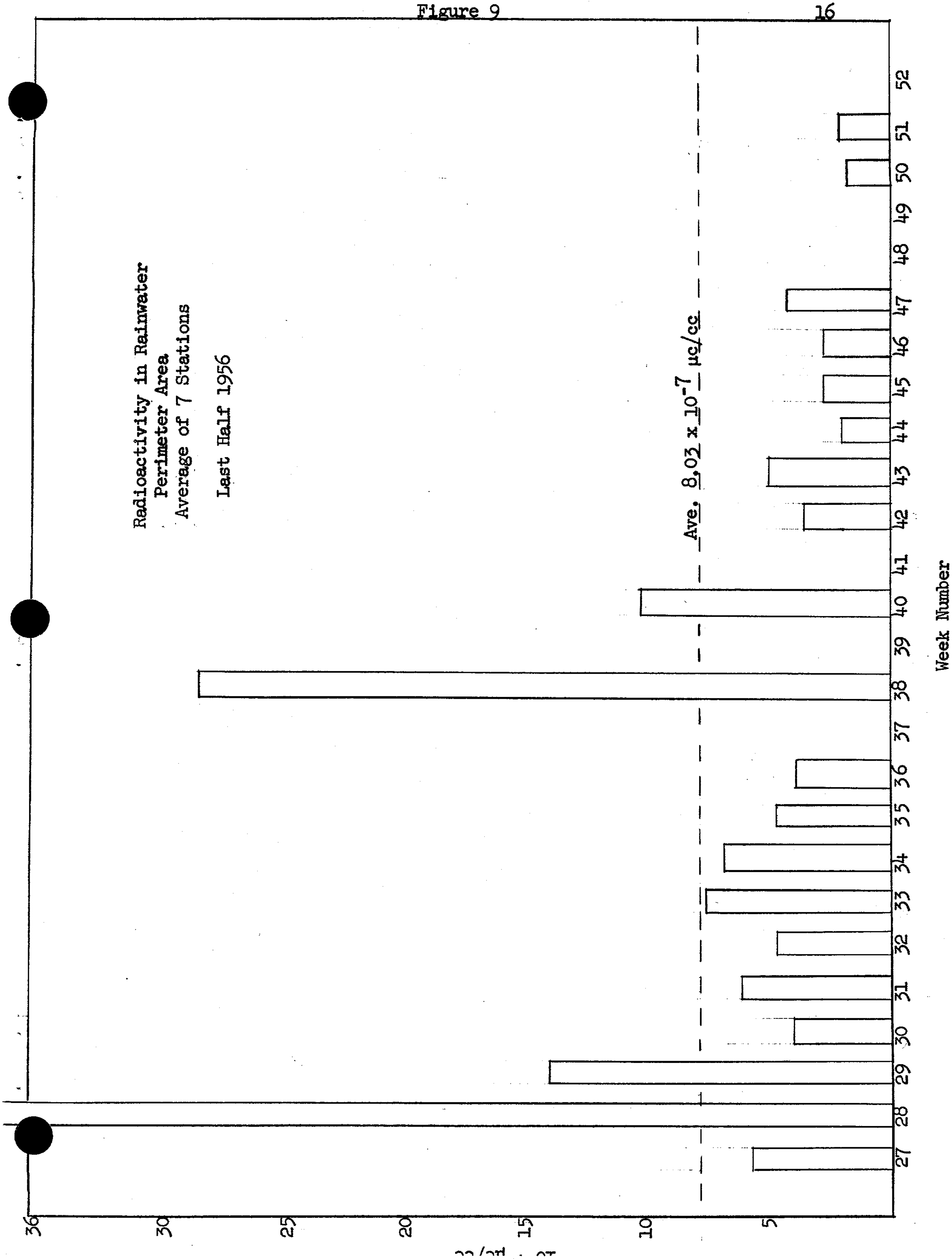
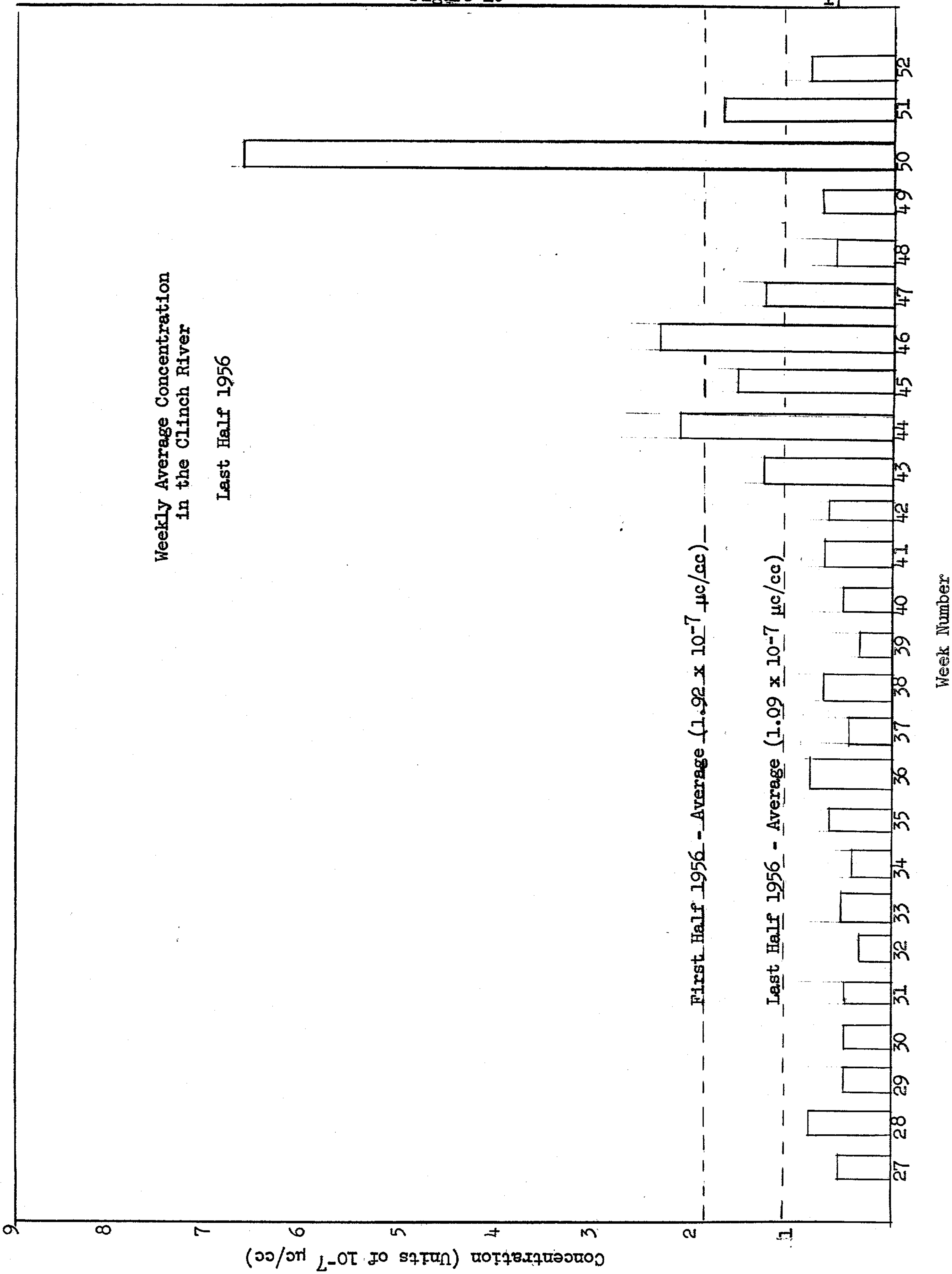

Radioactivity in Rainwater
Perimeter Area
Average of 7 Stations
Last Half 1956
Ave. 8.03 x 10-7 µc/cc
Week Number
27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52
5 10 15 20 25 30 36

Figure 10


Weekly Average Concentration
in the Clinch River
Last Half 1956
First Half 1956 - Average (1.92 x 10$^{-7}$ μc/cc)
Last Half 1956 - Average (1.09 x 10$^{-7}$ μc/cc)
Concentration (Units of 10$^{-7}$ μc/cc)
Week Number
1
2
3
4
5
6
7
8
9
27
28
29
30
31
32
33
34
35
36
37
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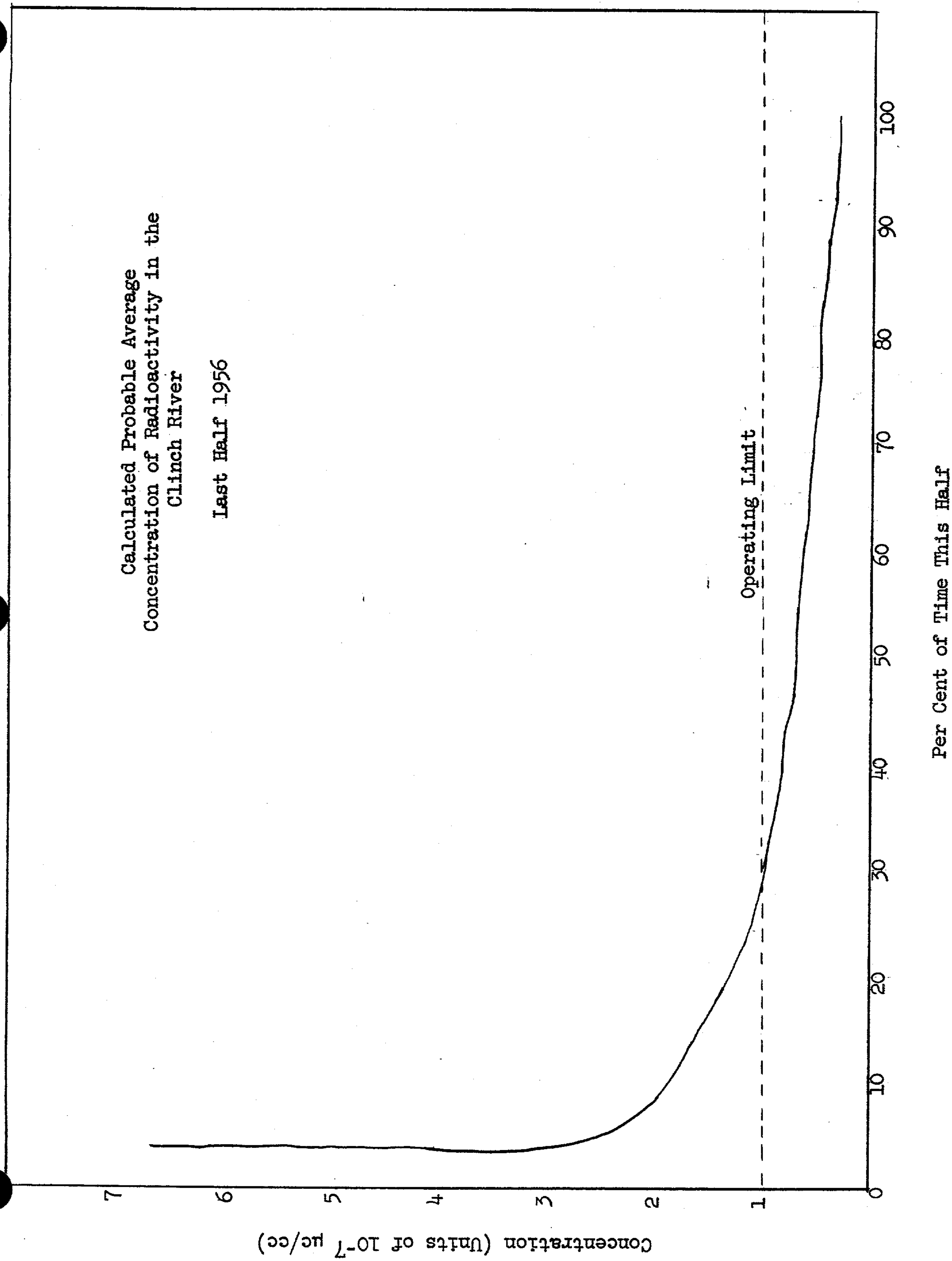
51
52

Figure 11



Calculated Probable Average
Concentration of Radioactivity in the
Clinch River
Last Half 1956
Operating Limit
Per Cent of Time This Half
Concentration (Units of $10^{-7}$ μc/cc)
0
10
20
30
40
50
60
70
80
90
100
1
2
3
4
5
6
7

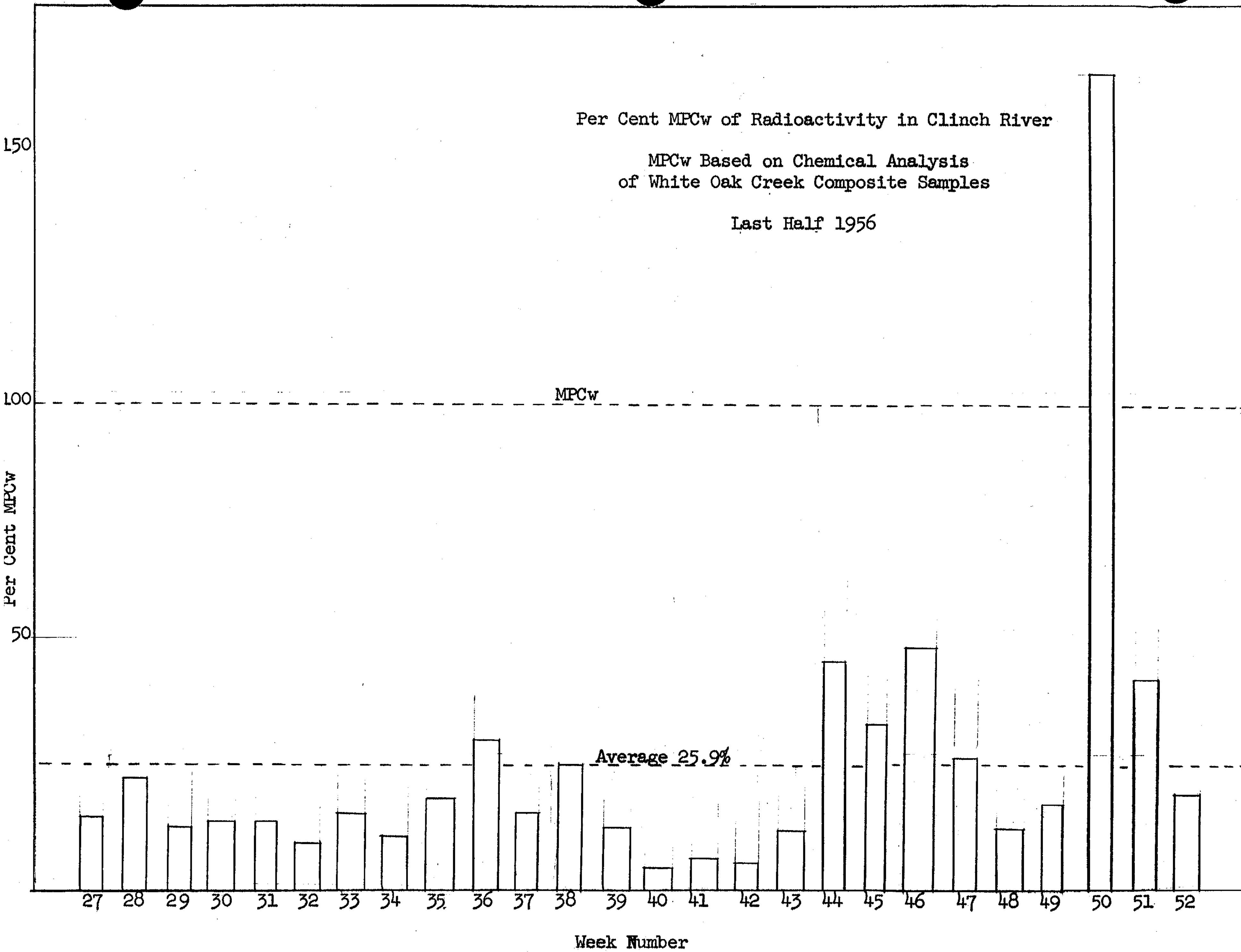
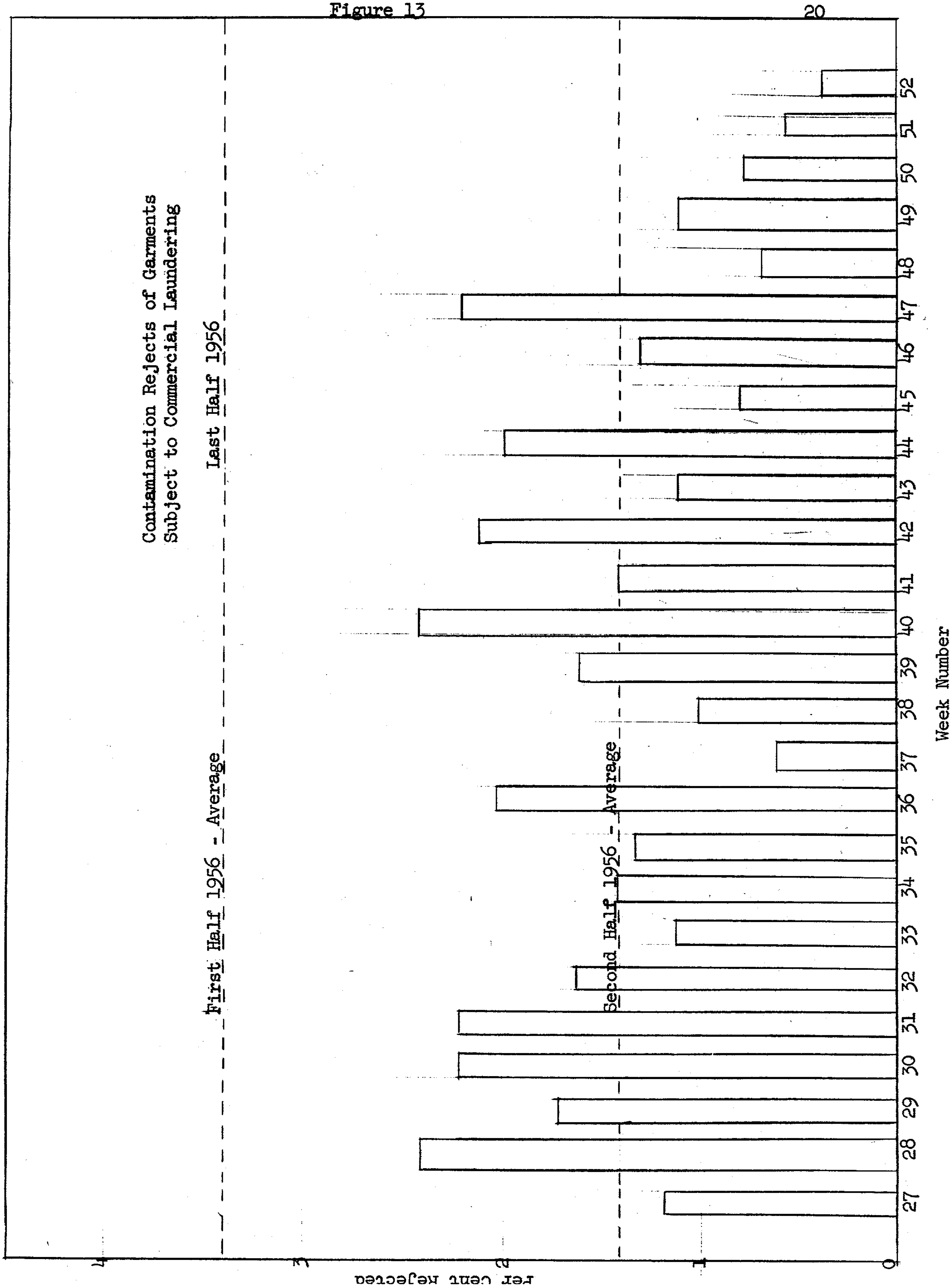

Per Cent MPCw of Radioactivity in Clinch River
MPCw Based on Chemical Analysis
of White Oak Creek Composite Samples
Last Half 1956
MPCw
Average 25.9%
Per Cent MPCw
150
100
50
27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52
Week Number

Figure 13



Contamination Rejects of Garments
Subject to Commercial Laundering
Last Half 1956
First Half 1956 - Average
Second Half 1956 - Average
Per cent Rejected
0
1
2
3
4
Week Number
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52

## SECTION II. ASSAYS-INSTRUMENTS

### Part A. Projects and Special Problems

#### 1. Photon Energy Response and Filtration[1]

Recent experiments by this group have extended to eight effective kilovolts (KVE) the previous data on photon energy response and filtration of DuPont 502 emulsion in monitoring film packets. Previously, data extended down to ~21 KVE. Information within this energy range (8 to 21 KVE) should prove useful for exposures near low energy x-ray machines and from certain radioisotopes.

Graph I indicates the response of the film with various filters to a wide range of photon energies.

#### 2. Comparison of Film Densities Produced by Absorbed Doses of Beta and Gamma Radiation[2]

A recently adopted concept is monitoring for absorbed doses rather than air doses. This poses the problem of determining film densities produced by beta doses absorbed in the film emulsion rather than densities produced by doses measured in air. The absorbed dose so measured may be extrapolated to the "surface" dose only if the effective energy of the radiation is known. Thus, for beta radiation, without knowledge of the energy, the only information available from a film meter is the blackening produced from the energy absorbed in the emulsion, which may have considerable absorber between it and the "surface". Experiments by the Standards Group have yielded the following:

1. The film density produced by placing a film wrapped in 7 $mg/cm^2$ absorber in contact with a slab of normal uranium (240 mrep/hr beta plus a few mrep/hr from gammas and secondary radiations) was 0.52 per rep of betas compared with 0.50 per roentgen of radium gammas.

2. A stack of film packets (552) was given a dose from a uranium surface of 5 rep, based on a beta dose rate of 240 mrep/hr. The densities produced at various depths were used to extrapolate to a "surface" (7 $mg/cm^2$) density value of 1.68. The corresponding density produced on a film exposed to 5 r from radium was 1.71.

   It appears, therefore, that for the betas from normal uranium, the density produced per absorbed rep is equal to the density produced per absorbed rep of "penetrating" gammas.

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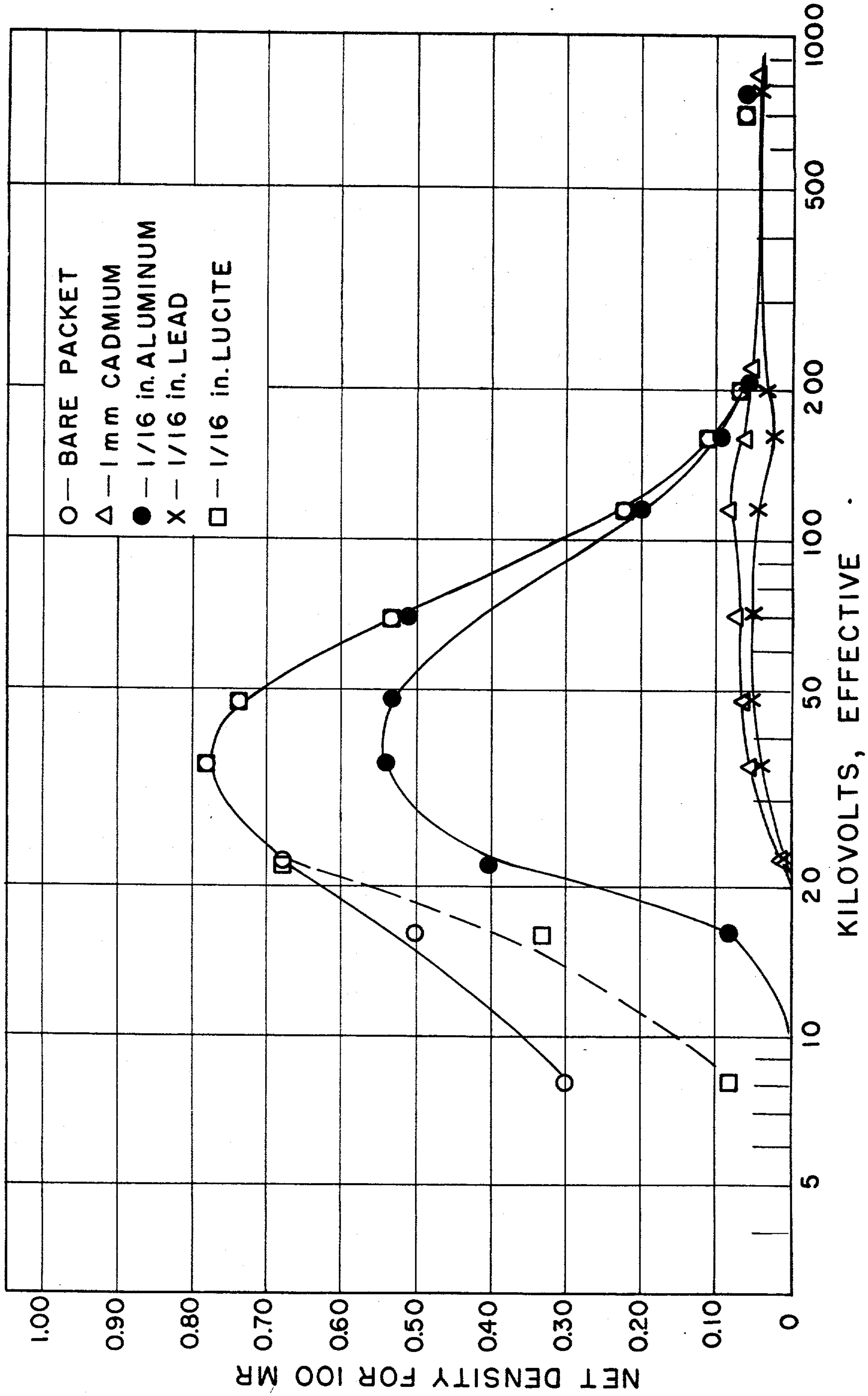
GRAPH I



Poddar[1] has reported that the density per dose produced by various beta emitters is a function of the specific ionization and the average energy of the betas, i.e.

$$\text{Density} = \frac{Q\ (\text{electrons/cm})}{\bar{E}}$$

and that the density per dose varies slowly with the average energy of the betas over a fairly wide range of energies.

Therefore, beta film calibrations are obviated where gamma calibrations are provided, and the absorbed beta dose at a tissue depth corresponding to the absorber interposed between the film emulsion and the incident radiation may be read directly from the gamma calibration curve.

3. "Intensification" of Film Blackening with Metallic Filters[3]

Tests performed by the Instruments Group have yielded information relative to the intensifying effect from photon radiation with metallic filters as follows:

a. The blackening in the area of the film covered by a metallic filter is greater than that with no metallic filter if the filter is oriented as a "back scattering" agent.

b. Little or no intensification is observable due to "fore scattering" by the metal.

c. The degree of intensification is directly proportional to the effective energy of the incident photons.

d. The degree of intensification is directly proportional to the atomic number of the metallic filter.

e. The degree of intensification is indirectly proportional to the mass per unit area of material of low atomic number (paper, plastic, air, etc.) between the metal and the film emulsion -- a few mg/cm$^2$ will reduce the effect appreciably.

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(1) Poddar, R. K., "On the Quantitative Relation Between Isotopic Beta Radiation and its Photographic Response", Indian Journal Physics, Vol. 29, No. 4, April 1955.

The following conclusions are assumed:

a. Intensification from forescattering may be unobservable with the photon energies tested (0.02 to 1.2 mev) due to the "intensification" being counteracted by absorption by the metal filter.

b. The intensification is probably due to secondary electrons produced in the metallic filter since the scattered radiation has very low penetrating ability.

c. The foregoing should be considered in applying heavy metal filters in film dosimetry.

4. Latent Image Stability in Monitoring Films[4]

Reduction of accumulated error in film dosimetry for small chronic doses may be accomplished if the monitoring film is worn for several weeks rather than one week; since the error is proportional to the frequency of processing.

One of the factors involved in increasing the time between processings is the latent image stability in the film emulsion.

The films in du Pont packet 552 have been tested to determine the degree of fading subsequent to exposure and prior to development. The maximum interval between exposure and processing was nine months. The minimum interval was a few hours. Temperature and humidity conditions to which the films were subjected during the experiment were those in a non-air conditioned laboratory. The average background was 0.02 mr/hr. Controls were used to obviate variation in processing and densitometry.

The results of the test indicate that monitoring films may be worn for periods as long as nine months without adding errors in dosage measurements due to the fading of the latent image.

5. Revision in ORNL Film Dosimetry Techniques[5]

The combination dosimeter-personnel identification badge in use since 1952 was redesigned in 1956 and a new badge should be placed in service sometime during 1957. Fig. 1 is a drawing of the current badge and its component parts. The basic difference between the current badge and the modified badge is the filters. Two of the filters in the current badge (Cu - .040" and Pb - .020") will be replaced with plastic and aluminum, .060" and .040", respectively. Table I shows the filter components of the new badge.

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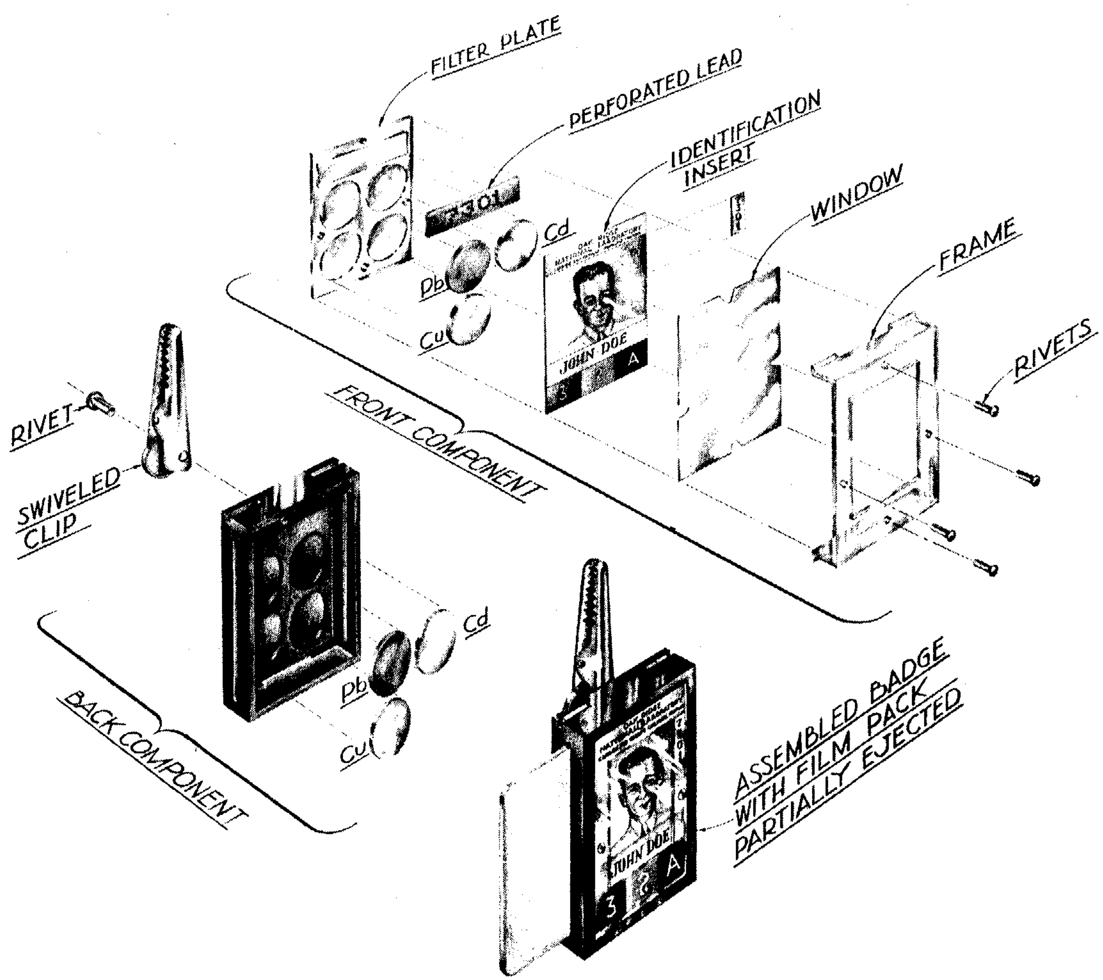


OAK RIDGE NATIONAL LABORATORY
BADGE METER

FIGURE 1

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TABLE I

Filter Components

(In order from front of badge)

| Filter Position | Metal Filter | Clear Window | Photograph | Identification Insert | Plastic (Filter Plate) | Film Wrapper | Approx. Total |
|---|---|---|---|---|---|---|---|
| Cadmium | 865 | 27 mg/cm$^2$ | 20 mg/cm$^2$ | 7 mg/cm$^2$ | 65 mg/cm$^2$ | 28 mg/cm$^2$ | 1000 mg/cm$^2$ |
| Aluminum | 370 | " | " | " | 65 mg/cm$^2$ | " | 500 mg/cm$^2$ |
| Plastic | --- | " | " | " | 186 mg/cm$^2$ | " | 270 mg/cm$^2$ |
| Window | --- | " | " | " | --- | " | 80 mg/cm$^2$ |

The method for determining the dose will be modified as follows: (1) The calibration curve will consist only of the radium gamma shield line; (2) all net densities from films will be referred to this curve to obtain the corresponding "reading" -- no units are assigned to these readings, but they are numerically equal to radium gamma millirads, air dose; (3) these readings are then converted to three tissue dose, viz., (a) moderately penetrating dose (Av. depth $\sim$ 1 mm), (b) dose to the lens of the eye (Av. depth $\sim$ 3 mm), and (c) penetrating dose (Av. depth $\lesssim$ 1 cm).

The method for converting the readings is based on several experiments, and, in brief, is as follows: Using the readings corresponding to the net densities at the window, plastic, and shield areas, (1) the penetrating dose (Dp) is equal to the shield reading, (2) the moderately penetrating dose (Dm) is equal to Dp plus the difference between the window reading and the plastic reading, and (3) the lens dose (Dl) is Dp or one-half Dm, whichever is greater, or the plastic reading, if this should be less than the quantity thus obtained.

6. Projection Minometer Modifications(6)

The Instrument Group has made certain modifications to the projection minometers, used by the Portals Group, to provide long term voltage stability, the same charging voltage on all minometers and greatly increased illumination lamp life. Two relatively simple alterations were made:

1. A central power supply was provided to operate several minometers. This supply provides 6.3 volts for the lamps and 150 $\pm$ .01 volts for the charging voltage.

2. A switch was provided on each minometer to operate the lamp and a pair of resistors with current drain equal to that of the lamp, situated near the lamp. When the lamp is switched off, the resistors are switched on and provide the heat required for temperature stability of the minometer.

The following benefits are derived from these modifications:

1. Prior to alteration, careful adjustment was required each day to maintain all minometers at approximately the same charging voltage. Now, all pocket ion chambers are charged to the same voltage and voltage adjustment is unnecessary.

2. The lamps, which heretofore had an average service life of a few days, now last several months.

7. Automatic Air Sampler(7)

The Assay-Instruments Group has assembled automatic air samples for (1) beta-gamma, and (2) alpha activity using a filter tape sampling head-transport system derived from an automatic air sampler manufactured by Research Appliance Corporation.

Fig. 2 is a photograph of the commercial instrument in which air is drawn by means of a bellows type pump through a strip of filter paper clamped in the sampling nozzle. A timer and switch arrangement activates a solenoid attached to the two-part sampling tube, the pump motor, and the motor which drives the take-up reel. The sampling cycle is as follows: The solenoid to the sampling nozzle is inactivated, the pump draws air through the tube and filter paper, and the take-up reel is inactivated. The change cycle is as follows: Simultaneously, the solenoid operates to remove the clamp from the filter paper, the pump is shut-off to remove the "drag" from the paper, and the take-up reel starts to rotate. After a time sufficient to transport a fresh area of paper to the sampling nozzle, the system switches to the sampling cycle. The duration of the sampling cycle may be adjusted for 30 minutes, 1 hour, and 2 hours.

The modifications and additions to this system include the following (Fig. 3):

1. A counter, connected with a count rate meter, recorder, and alarm signalling system, is mounted adjacent to the sampling nozzle. The previously collected sample is indexed, during the change cycle, under this counter for count-rate analysis. An end-window GM tube is used for beta-gamma and a scintillation counter is used for alpha.


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0 1 2 3 4 5 6 7 8 9 10 11 12

Fig. 2

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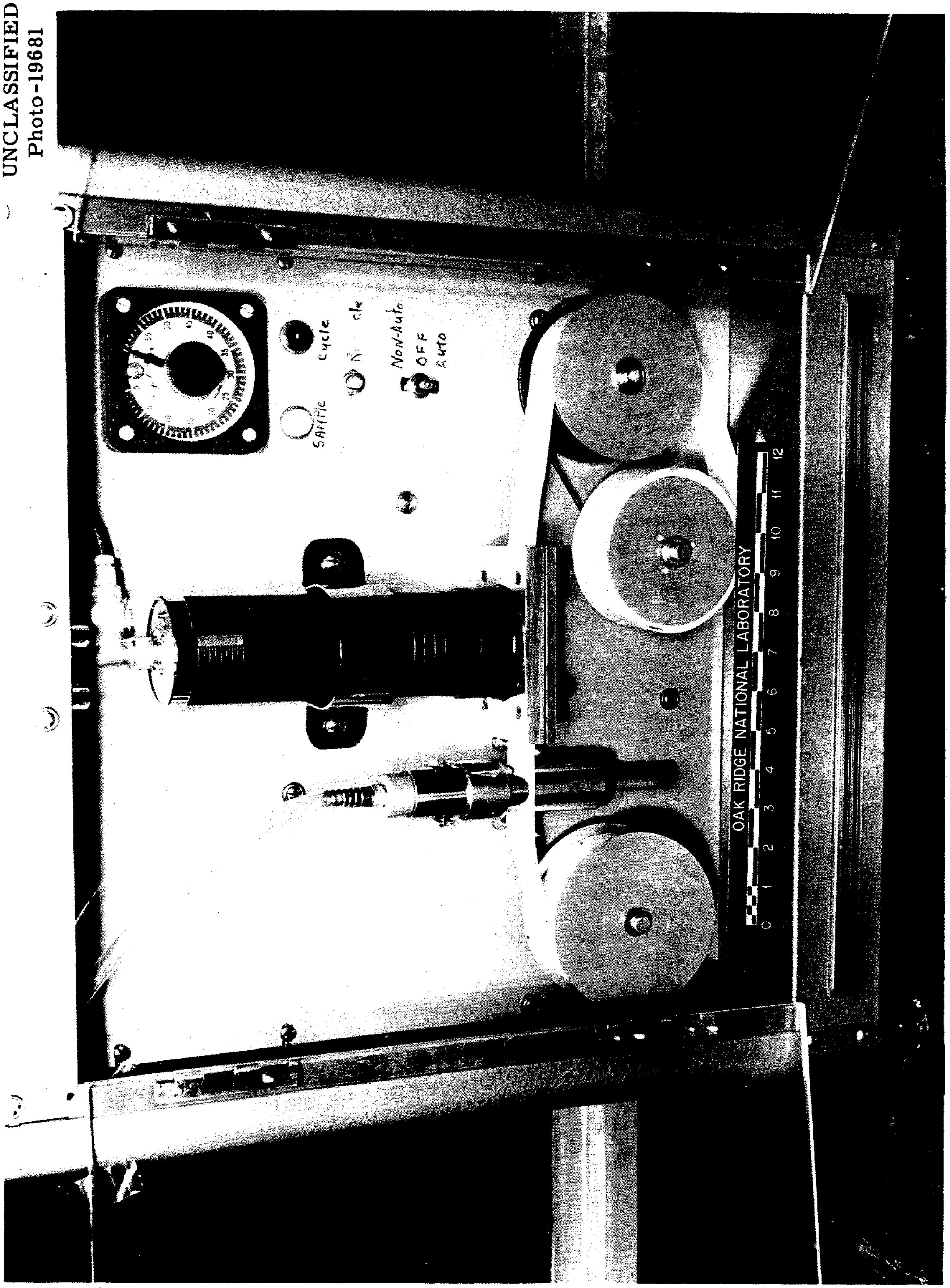


Fig. 3

2. The take-up reel has been replaced with a direct drive wheel and a spring belt driven take-up reel has been added.

3. A "cycle-flex" timer is used to permit greater flexibility in selection of sampling intervals.

4. An interval timer is used for accurately indexing the collected sample under the counter.

5. A "Gast" pump ( 1 cu. ft/min.) is used to replace the bellows pump (1/4 cu. ft/min.).

This instrument supplies information relative to the gross counting rate per sample and the effective half-life of the collected isotope(s). The samples may be given further analysis with other counting equipment.

8. Hand and Foot Counter

The Hand and Foot Counters developed by the Assays-Instrument Groups have been in service for several months. This is a low cost, relatively simple beta-gamma hand, foot, and clothing monitor.

The basic component of this instrument is an ORNL Quintector, a five channel count-rate device with an integral alarm independently operated by any one of the five rate meter relays. Four side-window GM counters are connected with the Quintector and mounted so that one counter monitors the left hand, one the right hand, one the left foot, and one the right foot; a fifth counter serves as a movable probe for checking other portions of the body or clothing.

Simple lead shields are provided for the four fixed counters. The whole assembly is mounted in a modified "Bud" rack.

9. Colorimetric Method of Determination of Thorium[8]

Tracer work is currently in progress in the north laboratory of Building 2008 to determine the efficiency of the colorimetric method for determination of thorium in body fluids. The maximum activity of the traces has been 200 c/m ($\sim$ 30% geometry). Using a water blank, the minimum detection level is 0.5 μ gm.

10. New Facilities and Instrumentation

An alpha and beta-gamma counter has been installed in the "Tracer Lab" of Building 2008.

The counting facilities, formally in Building 2001, have been moved to Building 3550.

1. Supplementary Information on Dosage Determination with Film, by D. M. Davis and E. D. Gupton.

2. Comparison of Film Densities Produced by Absorbed Doses of Beta and Gamma Radiation, Memo from E. D. Gupton to D. M. Davis.

3. "Intensification" of Films Blackening with Metallic Filters, Memo from E. D. Gupton to D. M. Davis.

4. Latent Image Stability in Monitoring Films, Memo from E. D. Gupton to D. M. Davis.

5. A Current Review of ORNL Dosimetry Techniques, by D. M. Davis, E. D. Gupton, and J. C. Hart (unpublished).

6. Projection Minometer Modifications, Memo from E. D. Gupton to D. M. Davis.

7. Automatic Air Sampler, Memo from E. D. Gupton to D. M. Davis.

8. Colorimetric Method of Determination of Thorium, Memo from P. E. Brown to D. M. Davis.

## Part B. Statistical Data

### 1. Assays and Measurements Unit

a. Counting Services - (Weekly Average)

| Type of Sample and Requestor | Calculations Required or Points Plotted | No. Counts Performed Alpha | No. Counts Performed Beta | Units Per Count* | Total Unit |
|---|---|---|---|---|---|
| Smears | | 2515 | 2612 | 1 | 5127 |
| Air Samples | 172 | 196 | 186 | 3 | 1664 |
| Area Monitoring | | 7.8 | 61.1 | 4 | 276 |
| ERDL | | | | 4 | 27.3 |
| Decay and Absorption Studies | 33.5 | | 69.7 | 4 | 346 |
| St. Louis Iron Works | | | | 4 | |
| Applied Radiobiology (Urinalysis Research) | | 4.8 | 35.8 | 4 | 163 |
| Sanitary Engineering | | | 48.5 | 4 | 194 |

| | |
|---|---|
| Average Units Per Week this Report | 7797 |
| Deviation of Weekly Average this Report from 1955 Weekly Average | -7.8% |
| Total Units Hnadled to Date this Year | 202,722 |
| Deviation of Weekly Average to Date this Year from 1955 Weekly Average | -6.9% |

### 2. Bio-Assays Unit

a. Sample Data

| Type Analysis | Total Samples for 1956 | Weekly Average | Deviation from 1955 Weekly Av. |
|---|---|---|---|
| Pu | 728 | 10.4 | + 4.0% |
| U | 1077 | 20.7 | +17.4% |
| Sr | 740 | 14.2 | -12.9% |
| Gross Alpha | 99 | 1.9 | -21.3% |
| Ra | 23 | 0.4 | -55.0% |
| Pb | 254 | 4.9 | +86.0% |
| Th | 125 | 2.4 | ** |
| Po | 28 | 0.5 | ** |
| Gross Beta | 43 | 0.8 | ** |
| Other | 52 | 1.0 | --- |
| Total | 3169 | 60.9 | + 4.7% |

*Unit = 2/3 min.

**No samples of this type processed in 1955.

b. Dose Data

| Type Analysis | Highest Conc. d/m/24 hr. sample | Number of individuals whose dose from internal sources ≥ .25 rem. |
|---|---|---|
| Pu | 2.1 | 0 |
| U | 467.2 | 0 |
| Sr | 285.2 | 0 |
| Gross Alpha | 3.4 | 0 |
| Ra | 0.35 | 0 |
| Th | 20.38 | 0 |
| Po | 373.0 | 0 |
| Gross Beta | 6955.2 | 0 |

3. Calibration Unit

a. Film Routine

| | |
|---|---|
| Average number of films calibrated per week | 132 |
| Deviation of the weekly average this report from 1955 weekly average | - 38% |
| Total Films calibrated | 3425 |
| Deviation of weekly average to date this year from 1955 weekly average | - 6% |

b. Instrument Routine

| | |
|---|---|
| Average number of instruments calibrated per week | 59 |
| Deviation of the weekly average this report from 1955 weekly average | -34% |
| Total instruments calibrated | 1535 |
| Deviation of weekly average to date this year from weekly average of 1955 | -15% |

4. Portable Instruments Repaired

| | |
|---|---|
| a. Average number of instruments repaired per week | 44 |
| b. Deviation of the weekly average this report from weekly average of 1955 | -12% |

c. Total instruments repaired to date this year — 1140

d. Deviation of weekly average to date this year from weekly average of 1955. — - 8%

5. Operation of Fixed and Semi-Portable Instruments*

| | | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|---|
| a. | Constant Air Monitors | 8255 | 1182 | 7073 | 126 | 86% | 1.5% |
| b. | Monitrons | 9906 | 435 | 9471 | 94 | 96% | 0.9% |
| c. | Hand & Foot Counters | 1397 | 83 | 1314 | 5 | 94% | 0.3% |
| d. | AC Poppies (Alpha & Beta-Gamma) | 2921 | 83 | 2838 | 0 | 97% | 0% |
| e. | Scalers (including Alpha Counters) | 3586 | 249 | 3337 | 9 | 93% | 0.2% |
| f. | Precipitrons | 1778 | 336 | 1442 | 0 | 81% | 0% |
| g. | Friskers | 1397 | 0 | 1397 | 0 | 100% | 0% |
| h. | Filtrons | 1270 | 0 | 1270 | 0 | 100% | 0% |
| i. | Disc Air Samplers | 1905 | 419 | 1486 | 0 | 78% | 0% |

1. Total number of "Instrument Days" where an "Instrument Day" is defined as the number of instruments times the number of work days in the quarter.
2. Number of "Instrument Days" for which operational reports were received.
3. Number of "Instrument Days" for which operations reports were not received
4. "Instrument Days" instrument reported out of service.
5. Per cent of "Instrument Days" not reported.
6. Per cent of "Instrument Days" instrument reported out of service.

SECTION III.

Part A. Salient and Non-Routine Items

During the last half of 1956, weekly film monitoring was discontinued and film exchange was placed on a 13 week basis. Personnel Monitoring effected a 31.2% reduction in personnel.

Part B. Statistical Data

1. Personnel Meters

a. Distribution and Performance of Pocket Meters

| | This Half | Weekly Average to Date This Half | Deviation of this half Wkly. Av. from 1st half Wkly. Av. |
|---|---|---|---|
| Meter distributed | 102843 | 3956 | + 15.5% |
| Readable Meters | 102799 | 3954 | + 15.4% |
| Non-Readable Meters | 44 | 2 | +100.0% |
| Non-Readable Pairs | 0 | 0 | 0 |
| Off-Scale Readings | 412 | 16 | + 33.3% |
| Off-Scale Pairs | 33 | 1.27 | + 03.3% |

b. Distribution and Processing Data of Film Meters

| | | | |
|---|---|---|---|
| West Portal | 22294 | 857 | - 63.4% |
| East Portal | 4265 | 164 | - 86.9% |
| Visitors | 20993 | 807 | + 15.3% |
| Rings, Packets, etc. | 2671 | 102 | - 17.1% |
| Routine Neutron Films | 2111 | 81 | - 75.3% |
| Special Neutron Films | 57 | 2 | 0 |
| Calibrations | 1712 | 66 | - 67.0% |
| Correspondents | 3138 | 1121 | +105.1% |
| Special x-ray films | 0 | 0 | 0 |
| Total Films Handled | 57248 | 2200 | - 56.0% |

c. Film Meter Data Loss

| | | | |
|---|---|---|---|
| Badge Meters not serviced | 379 | 15 | - 77.9% |
| Films Lost | 3 | .12 | +100.0% |
| Films Damaged | 40 | 1.54 | +100.0% |
| Total | 422 | 16.23 | - 76.5% |

2. Investigations Indicated This Half

a. From Pocket Meter Records

| | This Half | Weekly Av. to Date this Half | Deviation of this half Wkly. Av. from 1st Half Wkly Av. |
|---|---|---|---|
| Significant Total of 1500 or more | 15 | .58 | |
| Off-Scale Pairs | 50 | 1.92 | |
| Non-Readable Pairs | 0 | 0 | |
| Total | 65 | 2.50 | |

b. From Film Meter Records

| | This Half | Weekly Av. to Date this Half | Deviation of this half Wkly. Av. from 1st Half Wkly Av. |
|---|---|---|---|
| Quarterly Dose ($D_m$) of 2600 mrem or more, or Quarterly Dose ($D_p$) of 1300 mrem or more | 102 | 3.92 | |
| Lost or Damaged films | 57 | 2.19 | |
| Total | 159 | 6.11 | |

SECTION IV. Radiation Survey

General Research, Chemistry, and Operations Surveys

On July 23, an employee was contaminated while replacing a gasket on a Chalk River slug carrier located on the concrete pad at the west end of Building 3505. The contamination was reduced to background within a short time after the incident. Ref: "Contamination Incident" dated July 30, 1956.

A minor explosion, involving radioactive material, occurred in Building 3508 on August 6, 1956. Air samples taken in the building indicated no airborne activity. The floor in Lab. 5 was found to be contaminated and immediate clean-up steps were effective in removing the contamination. Ref: "Explosion in Lab. 5, Building 3508", dated August 6, 1956.

On August 14, a sample of radioactive material was accidentally dropped on the second level of Building 4505 resulting in building and personnel contamination problems. A section of tiled floor was removed and replaced during the decontamination process. Air samples taken during clean-up gave no indications of air activity. This incident is described in a special report, "Polonium-210 Incident in Building 4505", dated September 25, 1956.

Reactors, Accelerators, and Related Physics Surveys

During this period an upper limit of 1 r/hr at one foot was imposed on the movement of unshielded samples. Samples which gives rise to radiation levels above this value must be shielded before the owner can claim it. This move, taken in conjunction with the Reactor Operations Department, is a step in minimizing exposure to hot samples during transportation.

During July and August, studies were made by G. C. Cain and H. V. Heacker to determine the correlation between low level, but significant, air activity in Building 3001 and the discharge of ruptured slugs from the reactor into the canal. It was found that ruptured slugs continued to out-gas when discharged into the deep pit of the canal and the gases then drifted into the operating areas by connection up the stairwell. In order to combat this problem, the following procedures were recommended: (1) No deep pit purging during discharge, (2) canning quickly after discharge, (3) using hot laboratory ventilation system to pull air from canal. Records indicate significant improvement since the adoption of these three procedures.

During September an antimony-beryllium source was moved into Bethel Valley Church for some activation experiments. The gamma radiation from this source necessitated posting of radiation hazard signs on the door, the fence surrounding the church, and closing the access gate at the roadway. A public relations problem with people desiring entrance to the graveyard was solved by re-routing the fence to include the church but exclude the graveyard.

Two large radium-beryllium sources were removed from metallic uranium containers during the month of November. This operation involved 4 grams of radium and was performed by machining away enough of the uranium to permit removal of a corroded screw type plug. The job was handled without incident.

On December 18, 1956, one of the plutonium foils used in calibrating some scintillation counters in Room 12, Building 3550, was found to be leaking. Contamination of several areas resulted from the moving of this source before the leak was discovered. Ref: "Activity Hazard Incident Report No. RS-112-56".

During this period, an additional film badge was issued to all employees whose work involves probability of neutron exposure. This was done to allow weekly processing of neutron film in order to overcome the image fading on undesiccated film over the quarterly film processing cycle.

<u>ORNL, Y-12 Facilities</u>

On November 30, 1956, two incidents occurred in Building 9204-1 as noted below:

1. Spill of 612 pounds of thorium oxide in the blending room.

2. Failure of packing in Wilfrey Pump at the slurry blanket mock-up releasing about 150 pounds of thorium oxide in a slurry form. On December 17, 1956, the packing in the Wilfrey Pump failed again resulting in the spill of 12 pounds of thorium oxide. Special crews were called in to perform decontamination work. The results of body fluid analysis on personnel working in the area indicated no significant internal exposure. Ref: "Incident Report, Building 9204-1", dated November 30, 1956 and "Incident Report, Building 9204-1, Y-12", dated December 17, 1956.

During this period a film study of the residual proton beam from 86" cyclotron, located in Building 9201-2, Y-12, was made. A special NTA film packet was used as a method of determining the approximate proton flux as well as the number of protons per second forming the residual beam. Details of this study are recorded in a report entitled, "Film Study of Residual Proton Beam from 86" Cyclotron Located in Building 9201-2, Y-12", dated November 13, 1956.

During this period a special survey was made at the 44" cyclotron to determine neutron and gamma readings under various operating conditions. The information from this survey was used as a basis for making some recommendations for protection of personnel working in the vicinity of the cyclotron. Ref: "Radiation Survey Around 44" Cyclotron and Related Information", dated September 14, 1956.

SECTION V: Technological Studies

During the second six months of 1956, slightly over half the effort of this section was applied directly to consideration of various aspects of reactor hazards. These included the extension of general studies of the hazards of release of fission product gases. The general containment problem calculations are approaching the point where they can be summarized to present the hazards of various leakage rates. These calculations were used to provide the ANP group with a parametric study of the hazards of various rates of leakage in the ART and with MPCa values for fission product gases. The paper "Reactors, Hazard vs Power Level" was presented at the winter meeting of the American Nuclear Society.

Included in varied technical assistance on a number of health physics problems of the division and of the Laboratory were a study of the problems of burning contaminated wastes and consultation on the methods and facility design for disassembly of the ART. A study was made of the feasibility of the use of activation activity for emergency team training in contamination problems. Other design problems considered were those of the ORR hot cells, a central high level laboratory, and the alpha and alpha-gamma hazards of work with transplutonic materials. Assistance was also given to the planning of a plant emergency radiation alarm network, the study of quarry disposal hazards, the evaluation of a bypass for White Oak Creek in event of major activity releases, and the estimation of release limits for $Kr^{85}$.

Discussions were held with 17 visitors (8 of whom were foreign) which principally related to reactor hazards but, in addition, dealt with other health physics problems such as waste disposal, etc.

Phone and letter inquiries dealt with fission product release hazards, the UCNC research reactor, the safety of medically administered $Co^{60}$ tracer quantities, and the relative exposure hazards of concentrations of $A^{41}$. Four papers were reviewed for authors and publishing editors, as well as regulations proposed for the control of radiation exposure.

J. C. Hart, Chief
Applied Health Physics

Data Compiled By: A. D. Warden
D. M. Davis
J. C. Ledbetter
T. J. Burnett
H. H. Abee
et. al.

JCH:mfm